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Model GLOW PLUG ENGINES

by C. E. BOWDEN

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PERCIVAL MARSHALL

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by

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FOREWORD

Glow plug ignition has taken America by storm. In one short year almost every model engine manufacturer turned to glow plug ignition. Once the slide began it was difficult to find in the advertisement columns of American magazines any manufacturer who did not offer at least one of his engines with glow plug ignition.

Glow plug ignition featured prominently in the speed events for model aeroplane boat and car. In this country it set up a new record for hydroplanes. All this took place whilst we in Britain developed our diesels to perhaps the highest standard in the world.

The glow plug engine has certain similar advantages to the diesel, such as the elimination of the weight of coil ignition to be carried by the model. On the other hand the glow plug motor has entirely different speed characteristics which should be understood by those using model internal combustion engines. The glow plug motor is undoubtedly becoming the engine of the moment in Britain, and I predict it will enjoy a great popularity when its advantages and disadvantages, too, are thoroughly understood.

It is to that end that I have written this short book in the hope that I may put fellow model enthusiasts into the glow plug ignition picture, and also indicate the sort of model in which the glow plug engine gives of its best.

I want to thank the following publications for kindly allowing me to make use of certain material. *Practical Mechanics*, *The Model Engineer*, *Model Aircraft*, *The Aeromodeller*.

C. E. BOWDEN.

Bournemouth, January, 1949.

CONTENTS

The History of Glow Plug Ignition and How It Works.

GLOW PLUG ignition is a new adaptation of one of the earliest forms of ignition for internal combustion engines. It was used in the very early days of motoring but died out as it was superseded by timed spark ignition which proved more suitable for the varying speeds required for road work. As the reader will see on reading this book, the glow plug motor must run at high R.P.M. due to the form of ignition. A road vehicle demands an engine with pulling powers at low revolutions as well as high speed. A model engine, for most purposes, runs at high speed, and therefore glow plug ignition is highly satisfactory. There are exceptions to this rule which we will discuss shortly.

This high speed running is most vital to successful operation of the glow plug motor and affects the type of model in which the engine is installed. It is a point that requires very careful consideration, for when an engine produces its power at high revolutions, then such components as propellers, or gear ratios on a car, must obviously be arranged to suit the high speed characteristics of the engine. If this is not done the performance is killed.

The glow plug motor has two factors in common with the model diesel. The engine carries no electrical batteries or other equipment in the air, on the water, or in a car. The advantages of this fact are obviously great. Models can be built lighter and it also opens up the way for smaller and more portable models. A light wing loading or a light water loading is of great benefit when stability in the air or on the water is being sought.

The second similarity between glow plug motor and diesel is a higher compression ratio than is used in a petrol

engine, although the glow plug motor does not have such a high compression ratio as the diesel. For instance, the average diesel has a compression ratio of approximately 16 to 1. A glow plug engine is satisfied with around 8 to 1 and upwards, whilst the petrol motor runs very well from about 5 to 1, to 6 or 7 to 1. "Compression ratio" means that an engine compresses a charge of gas in its cylinder, by squeezing that charge into a space, shall we say, six times smaller between piston and cylinder head as the piston rises in the cylinder on the compression stroke. Thus, if a given volume of gas is taken into the cylinder, it can be squeezed into any range of compression ratio by altering the distance between the top of the piston (at the top of its stroke) and the top of the cylinder head. If the reader will look at Fig. 2 he will see a cut-away view of the well-known "Ohlsson" glow plug engine which shows the piston in the cylinder. Because the piston is attached to the rotating crankshaft, which is reminiscent of the crank of a pedal cycle, the piston travels up and down in the cylinder. In the "two-stroke" engine, the piston travels up and compresses the gas which has been transferred from the crankcase to the cylinder, and when near the top of its stroke, termed top dead centre or T.D.C. for short, the compressed gases are fired. The resulting expansion of gases, generally termed "explosion" drives down the piston on its power stroke in the same manner that you or I push the pedal down on the power stroke when we are cycling. As the piston goes down the cylinder, it opens an exhaust port. The burnt gases rush out from this port into the atmosphere. This rudden rush of expanded gas causes the exhaust noise that excites the enthusiastic modeller but often upsets the general public's state of peace.

If the modeller is not sure of how the internal combustion motor functions he should study the description and sequence of the "two-stroke" engine given below, for almost all model engines are "two-strokes". A few

FIG. 1. SIMPLIFICATION OF IGNITION FOR MODEL INTERNAL COMBUSTION ENGINES

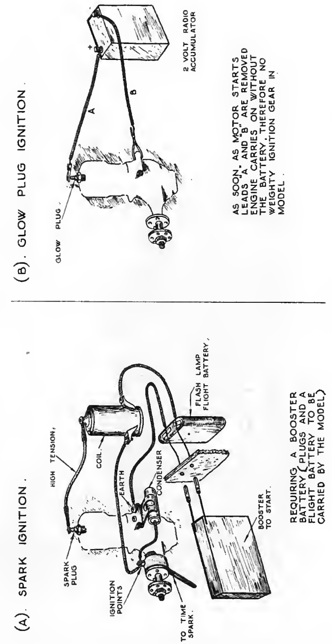
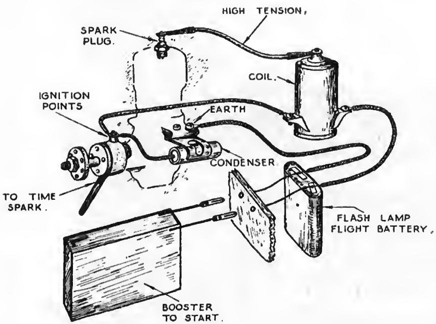


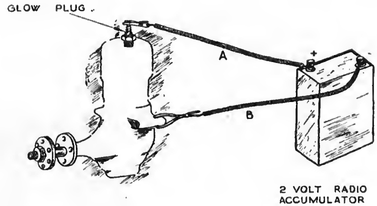
FIG. 1. SIMPLIFICATION OF IGNITION FOR MODEL INTERNAL COMBUSTION ENGINES.

(A). SPARK IGNITION.



REQUIRING A BOOSTER BATTERY (PLUGS AND A FLIGHT BATTERY TO BE CARRIED BY THE MODEL)

(B). GLOW PLUG IGNITION.



AS SOON AS MOTOR STARTS LEADS "A" AND "B" ARE REMOVED. ENGINE CARRIES ON WITHOUT THE BATTERY, THEREFORE NO WEIGHTY IGNITION GEAR IN MODEL.

" four-strokes " are made by private individuals, but the two-stroke is cheaper to manufacture and simple to operate, and is the normal type that is sold in a model shop.

Although it may sound foolish, it must be admitted the added staccato noise of the glow plug engine's exhaust note

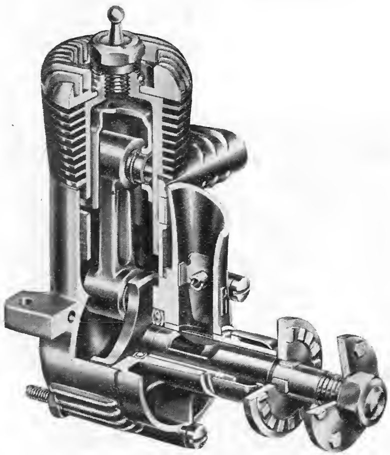


Fig. 2—The well-known " Ohlsson and Rice 23 " glow plug motor shown in section with robust connecting rod and crankshaft with rotary induction port. Ball races are fitted.

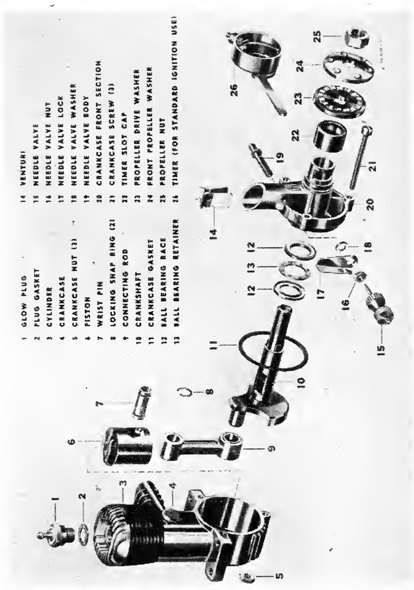
over that of a diesel, is exciting and *sounds* more powerful. It is therefore often called an advantage of the glow plug engine !

In Fig. 1 the reader will be able to understand how much more simple the glow plug engine is when compared to the older and more usual spark ignition motor, although the actual engine, except for its higher compression ratio, is fundamentally the same.

The History of Hot Point or Glow Plug Ignition.

Glow plug ignition is a general term for the specialised commercial names made popular by firms of model engine manufacturers. Thus, the American H & H motor introduced what seems to have been the first commercially available motor on these lines. This was called the " Hot Point Ignition H & H " motor. This engine was designed and tested before the last war and went into production in quantity early in 1946. The capacity was 7.4 c.c. and the weight 8 oz. The motor to-day has a terminal on the cylinder head, and in this respect is unlike all its competitors who place a detachable glow plug in the cylinder head. A three-volt battery is connected to the terminal and " earth " is via a resistance wire which is used to cut down voltage from new cells and obviate any burning out of the starting element. The latest H. & H. 45 engine claims to be " the only engine that gives you a fully exposed platinum coil for maximum efficiency in starting and operation."

Mr. Arden, the maker of the famous Arden motors renowned for their terrific performance for small capacity, and also for clean design, was the first to produce a glow plug in quantities under the trade name " glo-plug ". Many manufacturers at first used his plugs in their motors, some later producing their own for the commercial market. In the early days Mr. Arden experimented with very small glow plug motors, and I am indebted to him for kindly



sending me some photographs and particulars of these engines which I have included below, as they are of historical interest and were the forerunners of the general line of glow plug motor to-day. They also prove how very small models can be produced when using glow plug power. At the same time, Mr. Arden sent me one of his ball bearing standard Arden engines fitted with glow plug. The Arden engine is, of course, well known all over the world for its wonderful performance for size, and the inspiring exhaust note in keeping with the performance.

The best power is produced at the very high r.p.m. of 10,000 under load of air propeller. Twenty thousand r.p.m. are possible with flywheel running light, which gives one some idea of the outstanding performance of these little motors. As a result of Mr. Arden's kindness I was one of the first in this country to sample the advantages of glow plug ignition. Since then I have had most of the good British development engines in this class through my hands, as well as converting innumerable petrol motors to glow plug ignition.

Following the success of these early engines, well-known American manufacturers produced suitable motors or adapted their petrol engines to use glow plug ignition. All these manufacturers, including the British who followed the American lead, have used varying trade names to describe glow plug ignition, which in effect means a plug that glows continuously hot in the cylinder head whilst the engine is running. It must be understood that it is in no way a timed spark plug engine. A glow plug motor does not therefore have a contact breaker to time the spark as the petrol engine does, for there is no spark, and where a petrol motor has been converted to glow plug ignition the contact breaker gear is disconnected or better removed. There is a

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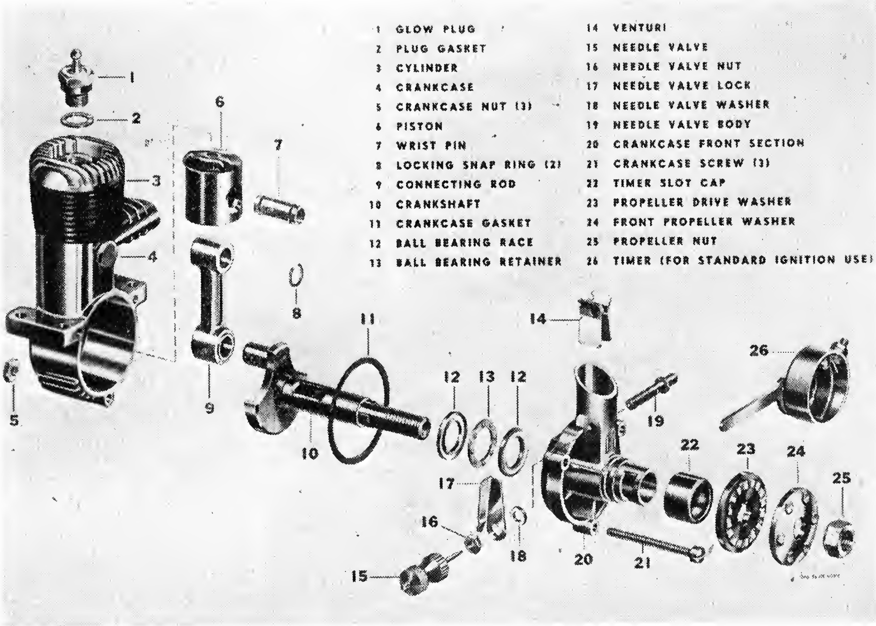
OPPOSITE. Fig. 3—This exploded view of the "Ohlsson 23" glow plug motor shows the component parts of the engine.



1 GLOW PLUG
2 PLUG GASKET
3 CYLINDER
4 CRANKCASE
5 CRANKCASE NUT (3)
6 PISTON
7 WRIST PIN
8 LOCKING SNAP RING (2)
9 CONNECTING ROD
10 CRANKSHAFT
11 CRANKCASE GASKET
12 BALL BEARING RACE
13 BALL BEARING RETAINER
14 VENTURI
15 NEEDLE VALVE
16 NEEDLE VALVE NUT
17 NEEDLE VALVE LOCK
18 NEEDLE VALVE WASHER
19 NEEDLE VALVE BODY
20 CRANKCASE FRONT SECTION
21 CRANKCASE SCREW (3)
22 TIMER SLOT CAP
23 PROPELLER DRIVE WASHER
24 FRONT PROPELLER WASHER
25 PROPELLER NUT
26 TIMER (FOR STANDARD IGNITION USE)

certain amount of friction and energy required to drive a contact breaker. See Fig. 1.

The Petrol Motor and the Glow Plug Engine compared.

Perhaps it is best to explain to the novice that normal spark plug ignition has a coil to create the high voltage spark and this spark is mechanically timed to take place when the piston is at a chosen point in the cylinder near the top of the stroke, i.e., T.D.C. Thus, if the spark is timed to occur early, just before the piston reaches the top of its stroke, the motor will run fast. If the spark occurs later the motor can be made to run slowly. The spark timing can be varied by moving a control lever.

The glow plug on the other hand is always glowing whilst the engine is in operation, and as we shall see shortly, the

Fig. 4—Mr. Arden, the American enthusiast and manufacturer, made one of the earliest "Glo-plug" motors. The engine shown weighs 87 grains and has over 200 hours running to its credit. a bore of 0.220" and a stroke of 0.220".

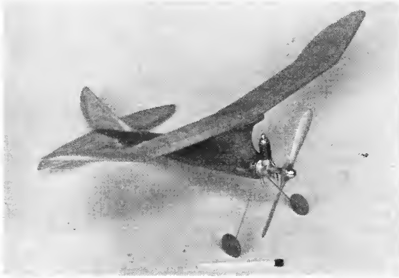


Fig. 5—Surely one of the smallest free flight glow plug models. The span is 12" and total weight, ready to fly, 208 grains. The engine has a bore of 0.187" and stroke 0.220". Built by Mr. Arden.

ignition of the gas is fixed except for a certain latitude of adjustment through using varying compression ratios and special fuels. This adjustment must remain fixed and *must be of an early nature which gives high speed running.*

The Americans found that generally speaking, glow plug ignition gave a greater performance, which was enhanced through not having to carry the weight of coil, condenser and battery. We are finding the same in this country.

The weight of coil, battery, etc., of the petrol motor is out of all proportion to the weight of a small petrol engine. Thus, the ignition gear of the petrol engine is often considerably more than the whole engine. For instance, a baby engine may weigh 2 oz., and the coil will weigh as much as the engine, namely, 2 oz., the condenser and the wiring another 1½ oz., and the flight battery from 3 to 4½ oz. The larger petrol motor can produce the power to

carry this weight and is not so adversely affected ; furthermore, the model can be larger in this case. The petrol motor, of course, has the advantage in the larger sizes of having a variable speed range which is advantageous for radio controlled model aeroplanes where climb can be controlled by variable speed range. On the other hand, hot racing engines of 10 c.c. and larger, such as the American " Dooling ", the " McCoy ", the " Hornet ", the " Ohlsson 60 ", the " Atwood Champion ", and many others when fitted with glow plug ignition cut out the weight of ignition gear which also improves the power weight ratio for speed events.

In this country, " Frog ", " Keil ", " E.D.", and " Nordec " leapt to this " new " ignition, following the American lead. Others are now following on.

The Two-stroke Cycle of Operation.

It is important to understand the cycle of operations of a two-stroke engine in general, before one discusses the operation of a glow plug engine in detail. Fig. 6 will serve to follow the working principle of the two-stroke.

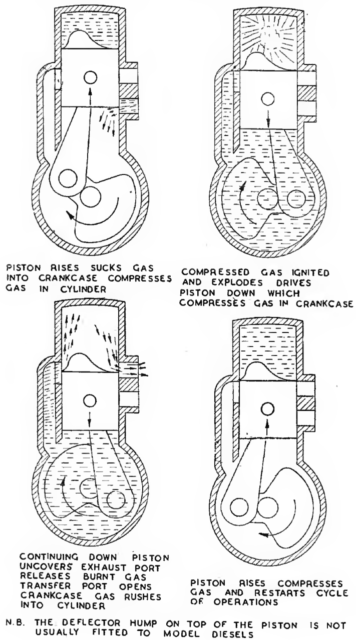
The two-stroke is very simple in operation, although it may be a little confusing to grasp.

Every time the crank makes a complete revolution the piston travels once down the cylinder and once up the cylinder.

The piston therefore completes two strokes for every revolution of the crank, and there is an explosion on every second stroke. That is why the engine is called a " two-stroke ".

The engine is kept going during the strokes, when there is no explosion, by the momentum of a flywheel or a propeller. For aeroplane work we use a propeller instead of a flywheel, and this propeller should be sufficiently

OPPOSITE. Fig. 6—The cycle of operation of a two-stroke engine.



heavy to act in lieu allied to the air resistance of the propeller.

The two stroke operates as follows :—

(1) There is one power stroke to every revolution of the crank shaft, or two strokes of the piston.

(2) The piston ascends the cylinder, causing a suction in the crankcase. (There must be no air leaks down bearings or from other sources.)

(3) As the piston nearly reaches the top of its stroke, an inlet port in the cylinder lower wall is uncovered by the bottom of the piston. A charge of gas is then sucked into the crankcase from the carburetter.

(4) The piston closes this port upon commencing its descent, and the charge in the crankcase is then compressed.

(5) As the piston nears the bottom of its stroke, with compression of gases at their maximum, the top of the piston uncovers a transfer port in the cylinder wall cut a little above the inlet port. This transfer port is connected to the crankcase, and the compressed charge now escapes to the combustion chamber in the cylinder head.

(6) A further ascent of the piston closes the transfer port and compresses the charge in the cylinder head, ready for ignition and the subsequent " explosion ".

(7) In a spark ignition engine the spark now occurs around the top of the stroke. In the glow plug motor there is the glowing element which fires the charge. The piston is driven down.

(8) As the piston goes down it opens a large exhaust port cut in the cylinder wall, and the burnt gases escape by reason of their own velocity, reducing the pressure in the combustion chamber to approximately that of atmosphere.

(9) The transfer port is again uncovered almost at the bottom of the stroke. See paragraph 4 above. A fresh charge of gas fills the combustion chamber as described before.

The cycle of operation then proceeds again as explained above. It will be understood that when the motor is running the induction takes place simultaneously with the compression of a previous charge (para. 5). Similarly, the compression of the crankcase charge (para. 3) takes place simultaneously with the explosion of a previous charge (para. 6).

Glow Plugs and Their Construction.

It is very important to fit the correct glow plug to a particular engine, and I shall have a few words to say on this point later. In the mean time let us see how this vital component is made up, for on its correct glowing powers the whole performance of the engine depends. A glow plug may glow either too fiercely or too weakly. In neither case will the engine function properly. It will be appreciated that the element and its length, in the form of reach into the cylinder where the element comes in contact with the burning gases, has an important bearing on the matter. It is also evident that engines with varying compression ratios, fuels and design factors must affect the glow plug's action. That is why I mention above that the correct glow plug should be fitted to suit the circumstances. Most readers will know from experience of either motor-cycles or cars that the correct spark ignition plug to suit a given set of engine and working circumstances is important, and that plug manufacturers issue charts in order to help the purchaser to make the right choice. The glow plug is even more touchy on this matter. An incorrect plug will often not carry on firing the engine after the battery leads have been detached, for it ceases to glow, and I know from experience that some plugs will produce much more power on certain engines than others. The Arden concern of America now sell plugs with detachable elements. One

runs hotter than the other. It is a matter of seconds to change over and see which element suits one's motor best.

The general make up of a glow plug will be seen in Fig. 7.

The glow plug is in effect a heater plug, generally similar in size and weight to a normal spark ignition plug. It is used to raise the temperature of the gases so that they ignite and operate the engine in a similar manner to spark plug motor, but without timed electrical spark ignition.

The electrical current (for starting only) at the element of a glow plug is a low voltage current and therefore does not give the modeller a shock should he unintentionally touch the plug or lead, as in the case of the spark plug's high tension current.

The glow plug has a coil of thin wire called an element, usually made of platinum or platinum iridium, in place of the usual electrodes of the spark plug. This thin element coil is heated by a battery for the start. After the start the battery is disconnected.

(A).
A GLOW-PLUG IN SECTION.

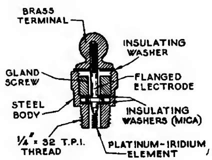


Fig. 7a—A glow plug in section.

(B).
ALTERNATIVE ELEMENTS.

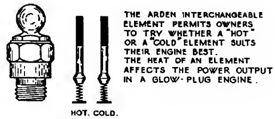


Fig. 7b—Alternative elements.

Too hot an element will reduce maximum speed of the motor by causing unduly early ignition, and too cold an element will not allow the motor to carry on firing after the starting battery has been taken away.

The super-speed boys in America found after much experiment that by moving the heating element up or down in the plug housing, the engine would gain or lose speed. This proved to them that the heating element position was a prime factor in obtaining the maximum horse-power from a given engine. It is not difficult to see that a hotter element ignites the charge better, and also earlier. It is in effect somewhat akin to advancing the ignition in a spark ignition petrol motor and like a spark-ignition engine, it is possible to over advance the spark and actually retard the all out revolutions of the engine.

There are three makers of plugs in Britain at the time of writing. Their products are each excellent, and if the modeller burns a plug out he should immediately suspect his methods rather than the plug. The correct method of operation is carefully given in this book, and if carried out plugs will seldom give trouble.

Bad usage can be briefly summed up—Incorrect starter battery voltage—Leaving the plug after the engine has started, with the battery in cicruit—using a pair of pliers to unscrew the plug or screw it into the cylinder. The pliers often slip on to the small hexagon nut which retains the element, thus damaging it. A plug should always be screwed in or out of the cylinder by the means of a spanner. A box spanner is preferable.

The firms manufacturing plugs are firstly the well-known "full size" concern K.L.G. who were first in Britain to produce model glow plugs in quantity. Their plug is known as the "Mini-Glo"—the second is the British version of the "McCoy Hot Point" glow plug, which is well known in America. This plug can be obtained with a long reach and therefore often suits converted petrol engines. A short reach version is also sold. The other plugs mentioned have short reach at the time of writing. The McCoy plug concern also make an adaptor which can be screwed into a cylinder head having the larger plug orifice of ⅜ in. All plugs at present are ¼ in. size. Many model petrol motors have the ⅜ in. hole. The third plug on the market is from the well-known model kit manufacturer of "Keil". The plug is known as the "Keil Kraft Gloplug".

How Glowplug Ignition starts and works the Engine. The "Carburetter" and the Starter Battery.

We have seen that the glow plug engine is essentially a normal petrol two-stroke motor but with a slightly raised compression ratio which burns a special fuel controlling speed of combustion. The fuel factors will be discussed shortly. The engine has no electrical gear to be carried by the model, but instead it has a heater plug which has an element that glows hot (*a*) by electrical energy from a starter battery which is subsequently disconnected, and (*b*) by the heat of compresson and combustion.

Let us discuss the carburetter which provides the "explosive gas", and we can then follow through in detail the starting and operating of a glow plug engine. This will put the newcomer to the type into the picture as he will experience it. We can then discuss the fuel, mounting the engine, tanks, and so on.

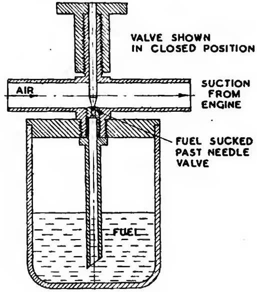


Fig. 8—The simple model type carburettor.

The Carburetter.

The carburetter can be seen in Fig. 8. On the average engine this is merely a mixing valve which allows the operator to vary the amount of fuel mixed with the air which is drawn into the engine by suction as already described. It is, however, important to grasp the fundamental but very simple action of a model "carburetter". A full-size carburetter is a complicated instrument of

compensating devices to deal with slow speed running, pulling, and running light, at low and high speed, and also speed all out running.

As out model engine runs flat out, or nearly so, a simple instrument in the form of an intake tube and a needle valve to control the fuel is sufficient, and what is more, important it actually works better than a complicated instrument, as I know from considerable experience, having used model compensated carburetters with float and pressure feed on racing hydroplanes and aeroplanes. Except for very special purposes they are unnecessary complications. They were much used in the early days of model engines and are now almost entirely forsaken by the wise.

It is interesting, in passing, to see why the full-size instrument must be complicated. The requirements of a full-size instrument also show why the model instrument can be so simple, when it is remembered that only flat-out performance is required by the average model. The " Solex " people in their excellent little brochure dealing with carburetters tell us that these ingenious instruments, which most of us take for granted, must be designed with the following conflicting purposes in view. They liken the engine's " diet " to that of the human being, in that it must be balanced if a proper output of useful working energy is to be attained. In the case of the internal combustion engine, the diet is made up of the correct proportions of air to fuel.

(1) Easy starting from cold or hot.
(2) Idling or tick over.
(3) Economy at normal speeds of traffic and touring.
(4) Maximum power at high speeds.

The respective correct mixtures for the above requirements are :—

for (1) 4 parts air to 1 part petrol (by weight).
(2) 10 parts air to 1 part petrol.

(3) $15\frac{1}{2}$ to $16\frac{1}{2}$ parts air to 1 petrol.
(4) 12 parts air to 1 petrol, decreasing progressively as the speed rises.

Our model carburetters are content with No. 4 maximum power at high speeds. This perhaps answers some of the questions asked by modellers as to why the model instrument can be so simple when the full-size carburetter is so comparatively complicated.

Now look at Fig. 8 and it will be seen that the air is sucked down a tube, which must, of course, be of the correct diameter. The air rushes past a jet, and on the scent spray principle, draws the fuel up and mixes it with the air on its way to the engine crankcase. The amount of fuel allowed to pass is controlled by a needle valve which can be operated and set by the modeller. By turning the needle valve knob clockwise (right handed) he reduces the fuel that can be drawn up, for the tapered needle goes down into the jet orifice and so fills it to a greater degree, until finally when the needle is screwed right home, the jet is entirely closed. By unscrewing the needle valve, more fuel is allowed to mix with the air flow. Needles vary in the amount of taper given. But we may say that an average opening for a glow plug motor is one and a half turns, whereas the average for a petrol engine is one turn. Obviously, where a manufacturer fits a highly tapered needle, more turns will be required.

When starting a model engine the ratio of fuel to air requires to be increased temporarily (*vide* the " Solex " Requirement No. 1). This is done by simply placing the finger over the intake tube of the model carburetter, and turning the motor over one or more times, which sucks in neat fuel. When the finger is taken away the normal air supply enters the crankcase as the engine is turned over. The reader will remember that the resulting explosive mixture is then transferred to the cylinder head via the transfer port (See Fig. 9).

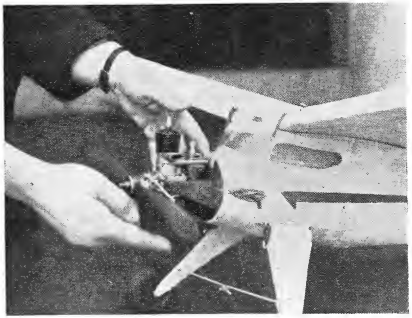


Fig. 9—To start the engine " choke " the carburettor with the finger over the intake and turn the engine over once or twice.

Tanks and Fuel Flow.

Fuel flow is much altered by tank location. This is dealt with in Fig. 10 which covers free flight or boat work other than round the pole hydroplane racing. This latter sport and control line flying introduce centrifugal force factors into the problem. Centrifugal force throws the fuel into the far side of the tank and naturally the pick up tube or line must be located at this side or the engine will be starved. Forward acceleration must also be considered or the fuel may pile up momentarily at the rear of a long tank, when the engine will be starved just at the moment when it requires a good flow of fuel, if the pick-up tube is situated at the front end or middle of the tank. The best position is therefore at the rear and far side of a tank, which the modeller may build himself from sheet metal. This form

of fuel supply is adequately dealt with in Chapter IV, diagram Fig. 27.

Incidentally the tank for a glow plug motor should be of metal because the fuel generally used dissolves the plastic or celluloid materials normally used by petrol engine manufacturers.

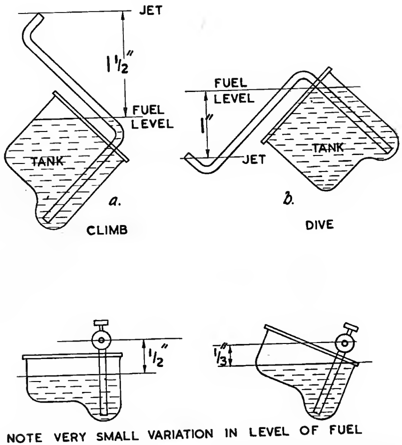


Fig. 10—The correct and incorrect way of fitting suction fuel feed on aeroplanes and boats. Control line requires further precautions. (Chapter IV, Fig. 27). The wrong method is, of course, above, correct below.